

## PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> :  B22F 7/06	A1	(11) International Publication Number: WO 00/38864  (43) International Publication Date: 6 July 2000 (06.07.00)
(21) International Application Number: PCT/IB99/02031		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
(22) International Filing Date: 21 December 1999 (21.12.99)		
(30) Priority Data: 98/11855 23 December 1998 (23.12.98) ZA		
(71) Applicant ( <i>for all designated States except US</i> ): DE BEERS INDUSTRIAL DIAMOND DIVISION (PROPRIETARY) LIMITED [ZA/ZA]; SEO Building, Corner Crownwood & Booyens Reserve Roads, Theta, 2001 Johannesburg (ZA).		
(72) Inventors; and		
(75) Inventors/Applicants ( <i>for US only</i> ): ADIA, Moosa, Mahomed [ZA/ZA]; 8 Nagel Street, Lakefield, 1501 Benoni (ZA). SIGALAS, Iacovos [ZA/ZA]; 112 Third Street, Linden, 2195 Johannesburg (ZA). MYBURGH, Johan [ZA/ZA]; 13 Shelley Drive, Kloofendal, 1724 Roodepoort (ZA). MFUMA, Lucas, Mthandeni [ZA/ZA]; 17381 Zone 1, 1852 Meadowlands (ZA). FRIES, Robert [DE/ZA]; 4 Bimam Road, Forest Town, 2001 Johhannesburg (ZA).		Published <i>With international search report.</i>
(74) Agents: HOOPER, Anthony, Robert, Lloyd et al.; Spoor and Fisher, (Rochester Place 173 Rivonia Road Morningside Sand, ton) P.O. Box 41312, 2024 Craighall (ZA).		
(54) Title: ABRASIVE BODY		
(57) Abstract		
<p>An abrasive body which comprises an abrasive compact bonded to a support along an interface, the abrasive compact presenting a working surface and a cutting edge or point on that surface, is provided. The abrasive compact in the abrasive body is characterised by the particle size at the working surface being finer than that at the interface and the particle size of the compact changing from the working surface to the interface in a continuous manner and with the substantial absence of any boundary between particle sizes. There is thus a continuous grading of particle size from the working surface to the interface.</p>		

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Republic of Korea	RO	Romania		
CU	Cuba	LC	Kazakhstan	RU	Russian Federation		
CZ	Czech Republic	LI	Saint Lucia	SD	Sudan		
DE	Germany	LK	Liechtenstein	SE	Sweden		
DK	Denmark	LK	Sri Lanka	SG	Singapore		
EE	Estonia	LK	Liberia				

- 1 -

## ABRASIVE BODY

### BACKGROUND OF THE INVENTION

This invention relates to an abrasive body containing abrasive compact.

Abrasive compacts are well known in the art and are used extensively for a variety of cutting, grinding, dressing, drilling and other applications. Abrasive compacts comprise a mass of abrasive particles bonded into a polycrystalline hard conglomerate. The abrasive particles are generally diamond or cubic boron nitride. Diamond abrasive compacts are also known as PCD and cubic boron nitride compacts are also known as PCBN.

Abrasive compacts have been produced in which there are at least two distinct zones or sections – the one being produced using coarse particles and the other fine particles. In these prior art compacts, there are clearly defined regions or zones containing the different sized particles and clearly defined boundaries between the regions and zones. Examples of compacts of this nature are described in US 4,311,490 and ZA 80/1829. A problem with abrasive compacts containing distinct zones or sections is that stresses are created in the compact layer leading to delamination and hence failure in use.

CONFIRMATION COPY

- 2 -

### SUMMARY OF THE INVENTION

According to the present invention, an abrasive body comprises an abrasive compact bonded to a support along an interface, the abrasive compact presenting a working surface and a cutting edge or point on that surface, the particle size of the abrasive compact at the working surface being finer than that at the interface, and the particle size of the compact changing from the working surface to the interface in a continuous manner and with the substantial absence of any boundary between particle sizes. There is thus a continuous grading of particle size from the working surface to the interface.

The range of particle size from the working surface to the interface will vary according to the nature of the abrasive operation to which the abrasive body is to be put. A typical particle size range will be 4 to 80 microns. In this case, the 4 micron particles will dominate at the working surface and the 80 micron particles will dominate at the interface. Between these two regions there will be a continuous change of particle size from 4 through to 80 with the substantial absence of any boundary between particle sizes. The absence of such boundaries has the advantage that any residual or sintering stresses which would have occurred between different diamond layers, as in the prior art compacts described above, are equally distributed over the entire compact layer and the mechanical properties of the abrasive body as a whole are improved.

The invention has particular application to abrasive bodies comprising diamond abrasive compacts or cubic boron nitride compacts.

The support will generally be a cemented carbide support. The cemented carbide may be any known in the art such as cemented tungsten carbide, cemented titanium carbide or cemented tantalum carbide.

- 3 -

According to another aspect of the invention, a method of producing an abrasive body as described above includes the steps of providing a mass of abrasive particles having a particle size range from fine to coarse, causing the particles in the mass to move producing a mass of particles which changes from fine to coarse particles in a continuous manner and with the substantial absence of any boundary between particle sizes, and subjecting the mass to elevated temperature and pressure conditions suitable to form an abrasive compact.

Abrasive particles come in various sizes. For example, there is a particle size defined as 40-80 microns. This means that the particles will range from 40 to 80 microns with the dominant amount of the particles being about 75 microns. Similarly, for a fine grade particle of size 5 to 15 microns, the particles will vary from 5 to 15 microns with the dominant amount of particles being about 10 to 12 microns. In the method of the invention, a mixture of particles of these two sizes or grades may be provided and the particles then caused to move relative to each other creating a continuous graded form in which the fine particles are separated from the coarsest particles by a region which has substantially no boundary between particle sizes.

The mass of abrasive particles may be suspended in a liquid and the particles caused to move to produce the particle mass of desired form due to the difference in particle size, i.e. the finer particles will tend to rise and the coarser particles tend to sink in the liquid. The liquid may contain a binder capable of setting to a coherent form. In this form of the invention, the liquid, once the particle mass of the desired form has been produced, is removed to allow the binder to set into a coherent form. The liquid will typically be water. Examples of suitable binders are cellulose ethers, acrylic resins, polyvinyl alcohols and butyral. The liquid may also contain a plasticiser.

- 4 -

The desired form of the particle mass may be produced by bringing a layer of fine abrasive particles into contact with a layer of coarse abrasive particles to produce a layered mass, and subjecting the layered mass to agitation to cause relative movement of the particles between the layers. The layer of fine particles will generally be placed on the layer of coarse particles which itself will typically be placed on a surface of the support.

It is also possible to produce the particle mass of the desired form by providing a mixture of fine and coarse particles and subjecting the mixture to agitation to cause relative movement between the particles to produce the particle mass of the desired form.

The conditions of elevated temperature and pressure necessary to produce an abrasive compact from the abrasive particle mass are well known and well established in the art. The elevated temperature will generally be in the range 1300 to 1600°C and the elevated pressure will generally be in the range 4 to 7 GPa.

#### BRIEF DESCRIPTION OF THE DRAWING

The drawing illustrates an electron microscope photograph of a PCD layer of the invention.

#### DESCRIPTION OF EMBODIMENTS

In a first embodiment of the invention, three grades of micron diamond were provided – 30, 12 and 4. The weight ratios of the various grades was 1:1.5:2. In these grades, the 30, 12 and 4 micron sized particles, respectively, will dominate, but each grade also contain larger and smaller particles in various amounts.

Each grade of micron diamond was suspended in water, the suspension containing 40 weight percent micron diamond, and 60 weight percent water. The three suspensions were mixed and agitated continuously using a magnetic stirrer. An appropriate volume of an aqueous solution of polymer binder was added to the slurry. Examples of suitable binders are cellulose ethers, polyvinyl alcohols, acrylic resins or butyral. A water-soluble plasticizer may also be added to the slurry. Examples of suitable plasticizers are polyethylene glycols and phthalate compounds.

The inside surface of a flat glass dish of suitable diameter was covered with a release agent. The aqueous diamond slurry was transferred quantitatively into the glass dish. The glass dish with the slurry on it was placed in an ultrasonic bath, which was in operation, and left there for 15 minutes.

The dish was carefully removed and transferred to a drying oven set at about 60°C. When most of the water had evaporated, but with some moisture still being present, the thus produced casting was cut or punched into the required shape and size and carefully removed from the dish. The casting was then allowed to dry completely.

The casting was placed on a surface of a tungsten carbide substrate or support to form an unbonded assembly. The unbonded assembly was placed in a reaction capsule which itself was placed in the reaction zone of a conventional high temperature/high pressure apparatus. The contents of the reaction capsule were subjected to a temperature in the range 1300 to 1600°C and a pressure in the range 4 to 7 GPa. These conditions were maintained for a period of about 20 to 30 minutes.

Recovered from the reaction capsule using conventional techniques was a product comprising a diamond compact or PCD layer bonded to a cemented carbide substrate. This product was EDM cut and polished on edge to determine the degree of sintering of the PCD layer and the appearance thereof. Figure 1 illustrates an electron microscope photograph of the PCD layer. It will be noted from the photograph that there is a zone of the fine particles at 10 and a zone 12 of coarser particles and a zone 14 of the coarsest particles. The transition between the zones is continuous and essentially free of a boundary or interface. The cemented carbide substrate is bonded to the lower surface of zone 14.

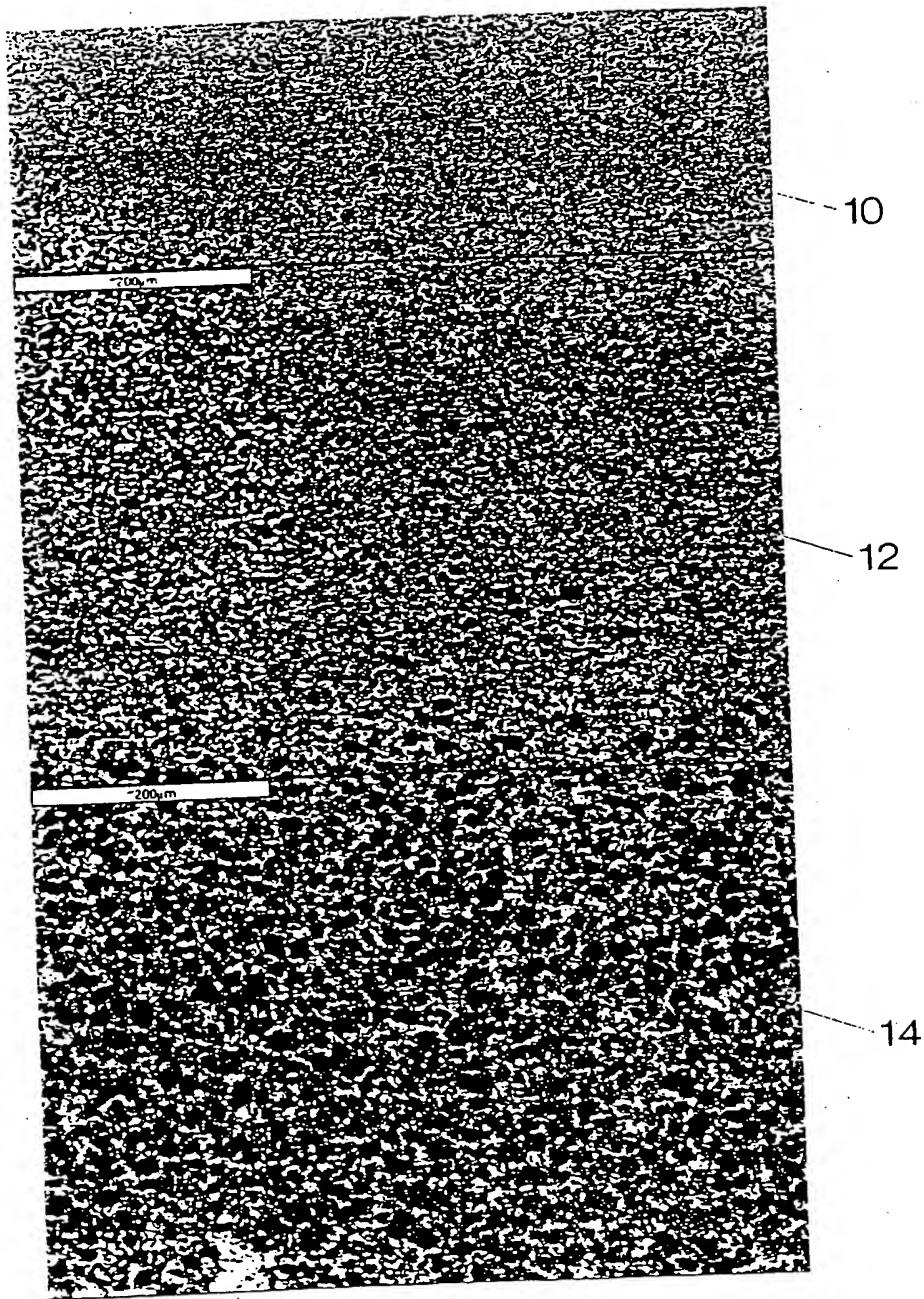
In another embodiment of the invention, a cemented carbide substrate in disc form was provided. A recess was formed in the one flat surface of the disc. Placed in the recess was a layer of 30 micron grade diamond and on top of that a layer of 4 micron grade diamond. This formed an unbonded assembly which was then subjected to vigorous agitation. On agitation, particles from the fine layer moved into or dispersed into the coarse layer producing a diffuse interface or boundary between the two layers. The unbonded assembly was then subjected to elevated temperature and pressure conditions as described above, to produce a diamond compact or PCD of the diamond particles which was bonded to the cemented carbide. The sides of the disc are removed to expose a diamond cutting edge. The compact region with the coarsest particles was adjacent the compact/carbide interface and the region with the finest particles was at the cutting edge.

CLAIMS

1. An abrasive body comprising an abrasive compact bonded to a support along an interface, the abrasive compact presenting a working surface and a cutting edge or point on that surface, the particle size of the abrasive compact at the working surface being finer than that at the interface and particle size of the compact changing from the working surface to the interface in a continuous manner and with the substantial absence of any boundary between particle sizes.
2. An abrasive body according to claim 1 wherein the range of particle size from the working surface to the interface is from 4 to 80 microns.
3. An abrasive body according to claim 1 or claim 2 wherein the compact is a diamond abrasive compact.
4. An abrasive body according to any one of the preceding claims wherein the support is a cemented carbide support.
5. A method of producing an abrasive body according to any one of the preceding claims includes the steps of providing a mass of abrasive particles having a particle size range from fine to coarse, causing the particles in the mass to move producing a mass of particles which changes from fine to coarse particles in a continuous manner and with the substantial absence of any boundary between particle sizes, and subjecting the mass to elevated temperature and pressure conditions suitable to form an abrasive compact.

6. A method according to claim 5 wherein the mass of abrasive particles is suspended in a liquid and the particles caused to move due to difference in particle size, to produce a particle mass of the desired form.
7. A method according to claim 6 wherein the liquid contains a binder capable of setting to a coherent form and the liquid, once the particle mass of the desired form has been produced, is removed to allow the binder to set into a coherent form.
8. A method according to claim 7 wherein the binder is selected from cellulose ethers, acrylic resins and polyvinyl alcohols.
9. A method according to any one of claims 6 to 8 wherein the liquid contains a water-soluble plasticiser.
10. A method according to claim 9 wherein the plasticiser is selected from polyethylene glycols and phthalate compounds.
11. A method according to any one of claims 7 to 10 wherein the coherent form of the particle mass in the desired form is placed on a surface of a support such that the coarsest particles are adjacent to or on that surface.
12. A method according to claim 5 wherein a layer of fine abrasive particles is brought into contact with a layer of coarse abrasive particles to produce a layered mass and the layered mass is subjected to agitation to cause relative movement of the particles between the layers.

13. A method according to claim 12 wherein the layer of fine particles is placed on the layer of coarse particles.
14. A method according to claim 12 wherein the layer of coarse particles is placed on a surface of a support.
15. A method according to claim 5 wherein a mixture of fine and coarse particles is provided and the mixture is subjected to agitation to cause relative movement between the particles to produce the particle mass of the desired form.
16. An abrasive body according to claim 1 and substantially as herein described with reference to the accompanying drawing.
17. A method according to claim 5 substantially as herein described with reference to the accompanying drawing.



## INTERNATIONAL SEARCH REPORT

Int. Application No  
PCT/IB 99/02031

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B22F7/06

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B22F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 806 406 A (SANDVIKENS JERNVERKS) 23 December 1958 (1958-12-23) page 3, line 3 – line 112	1,2,4,5, 16,17
Y	EP 0 619 379 A (TOTO LTD) 12 October 1994 (1994-10-12) claims 1,15,17	6,7
A	US 2 888 247 A (D.W.HAGLUND) 26 May 1959 (1959-05-26)	1
A	EP 0 111 600 A (REED ROCK BIT CO) 27 June 1984 (1984-06-27) page 8, line 8 – line 25; claim 39	6,7

Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the International filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the International filing date but later than the priority date claimed

- \*T\* later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed Invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed Invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the International search

13 April 2000

Date of mailing of the International search report

20/04/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patenttaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

Schruers, H

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IB 99/02031

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 806406 A		NONE	
EP 0619379 A	12-10-1994	AU 4833593 A WO 9406947 A US 5972067 A US 5653924 A US 5943546 A	12-04-1994 31-03-1994 26-10-1999 05-08-1997 24-08-1999
US 2888247 A	26-05-1959	NONE	
EP 0111600 A	27-06-1984	NONE	

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**

**THIS PAGE BLANK (USPTO)**